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ABSTRACT

LINGUAL FUNCTION AND ARTICULATORY COMPETENCE

by Donna E. Swenson

Dworkin (1979) states that, of the 2.5 million children and young adults in the United States with a communication problem, 60% have a functional articulation disorder for which no psychologic or physical problem can be found. The oral mechanism examination is an established part of a speech and language examination for testing these children, and the tongue is the most important organ for speech (Johnson, Darley, and Spriestersbach, 1963). However, no conclusive rationale for the procedure or objective lingual measurements have been established. This research, therefore, was designed as a pilot study to investigate whether lingual structure and function are linked to articulatory competence.

Twenty-four children from the four-year-old population were selected from Riverside, California preschools as subjects for study. These children had hearing and receptive vocabulary which were within the range of normal limits, as tested by a hearing screening and the revised Peabody Picture Vocabulary Test. They were categorized according to articulatory ability into one of three groups: normal, moderate, or severe. A 30-item protocol was developed, based on the Examination of Tongue subtest from the Dworkin-Culatta Oral Mechanism Examination. For 22 items, literature definitions and available norms were used in scoring each subject as "normal" or "abnormal." For the remaining eight items,

which did not have norms reported in the literature, objective data were collected. For example, a strain gauge assembly was constructed to objectively measure lingual strength.

Each child was examined following the protocol developed by this investigator. Results of the examinations were analyzed to determine if any of the tasks were significant between the three articulation groups. One item out of the 30, which tested diadochokinetics using sequential syllables was significant. None of the other 29 items was significant between the three groups. In view of this finding, the null hypothesis was accepted, except in sequential syllable diadochokinetics, indicating that very little relationship exists between lingual structure and function, and articulatory competence. This researcher has, therefore, concluded that performing an oral mechanism examination on all patients presenting articulation disorders is of limited value.

LOMA LINDA UNIVERSITY

GRADUATE SCHOOL

LINGUAL FUNCTION AND ARTICULATORY COMPETENCE

by

Donna E. Swenson


A Thesis in Partial Fulfillment
of the Requirements for the Degree of Master of Science
in the Field of Speech-Language Pathology

September, 1982

Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a thesis for the degree of Master of Science.

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CHAPTER ONE

THE NATURE AND SCOPE OF THE PROBLEM

As children grow and develop they seek to understand the world in which they live. According to Wood (1976), the essential key to this is effective communication through understanding and using language. Many children, for some reason or other, do not develop normal speech and/or language. The speech-language pathologist must know what factors influence speech and language development so that she can facilitate development of those skills which are delayed or disordered.¹ Winitz (1969) reviewed the research which has been completed prior to 1970 dealing with the causation of misarticulation and stated that there "seems to be no single cause for the disorders of articulation." To best remediate a child's speech disorder, the speech-language pathologist tries to discover possible relationships between the disorder and other language processes in the child. This is accomplished through a formal speech-language evaluation.

One part of the speech-language evaluation is the oral mechanism examination (Dworkin and Culatta, 1980a). The oral mechanism includes "the respiratory mechanism, larynx, tongue, hard and soft palates, teeth, lips, pharynx and nasal cavities" (Johnson, Darley, and Spriestersbach,

¹For purposes of simplicity and ease in reading, the following pronouns will be used consistently throughout this paper: she--the speech-language pathologist or speech-language specialist, he--the child or subject being studied.

1963). The oral mechanism examination includes inspection of the structure and analysis of the function of the oral mechanism. Researchers state that "accurate assessment of this mechanism is best accomplished by a systematic and comprehensive examination approach" (Dworkin, 1978c). Although there are many tests used in a speech and language evaluation which offer normative data, specific test results, and therapy implications, there are little or no normative data relative to performing or evaluating the results of an oral mechanism examination. The primary reason for the lack of specific performance scores and norms is because an oral mechanism examination involves judgments rather than direct measurements. (Johnson, et. al., 1963). Even in a "normal" group of speakers, articulatory structures are variable (Emerick and Hatten, 1979). Based on experience, each speech-language pathologist must make her own evaluations of each client's speech structures and how well these structures function. The combined effect of several deviant structures on function has been suggested as a possible cause of deviations in speech; however, research to support this is inconclusive. People with deviant oral structures are often able to compensate for their problems when speaking (Johnson, et. al., 1963).

In the process of performing an oral mechanism examination, the speech-language pathologist is particularly concerned with determining whether or not the individual is able to function with the structures he has, including any structural deviancy (Johnson, et. al., 1963). Each structure of the oral mechanism is essential to speech. The lips, teeth,

tongue, hard and soft palate, fauces, and nasal cavities are all coordinated to produce accurate speech. However, the tongue has been defined as "one of the most important structures of the oral mechanism" (Johnson, et. al., 1963) and the "most adaptable organ of articulation" (Mason, 1980). Thus, the articulatory structure most directly correlated to speaking ability is the tongue. Nevertheless, researchers such as Mason question whether non-linguistic tongue function is related to speech. Mason states that speech and non-speech activities are controlled by different mechanisms in the central nervous system. He asserts that "there is no logical rationale for testing non-speech tongue movements . . . to assess the potential for tongue function in speech activities (Mason, 1980). If there actually is no rationale for testing non-speech tongue movements, professional time should not be spent which results in professional fees being charged for this portion of an oral mechanism examination. Lack of conclusive evidence in this area exists; therefore, further investigation is warranted.

THE PROBLEM

The purpose of this research was to perform a pilot study which involved investigation of whether appropriate lingual structure and function are linked to articulatory competence, thus justifying performance of the lingual subtest of an oral mechanism examination. This researcher designed a method for norming a protocol, developed from the Examination of Tongue subtest contained in the Dworkin-Culatta Oral Mechanism

Examination (D-COME), to be used by speech-language pathologists in examining oral mechanisms using a more objective procedure than currently is available.

The Problem Statement

The following question was investigated:

Does the appropriateness of lingual structure and function correlate with the level of articulatory competence?

Limitations

The research population was limited to preschool children who were between the ages of four years, zero months and four years, eleven months and who were attending some type of preschool. The population was from an area conveniently available to the researcher, that is, the Riverside, California area.

HYPOTHESIS AND ASSUMPTIONS

Null Hypothesis

The null hypothesis stated "there is no statistically significant correlation between a subject's performance on a lingual structure and function test and his articulatory competence."

Assumptions

It was assumed that the two children randomly chosen from each articulation group who were tested to verify interjudge reliability were

a representative sample of that group. It was also assumed that the specific preschool population of this study was not unlike similar preschool populations with respect to the conditions and variables being studied.

DEFINITION OF TERMS

Arizona Articulation Proficiency Scale: Revised (AAPS:R)

This is a single-phoneme test in which vowels, diphthongs, and consonants are tested. Each phoneme is assigned a relative value according to frequency of occurrence in the language, to yield an overall percentage of intelligibility. This percentage allows articulation proficiency to be divided into categories. The categories for children four years, zero months to four years, eleven months are:

- a. Normal Articulation: Speech that receives one of the following accuracy scores:

4-year-old children	81.0-98.0%
4½-year-old children	85.5-98.5%

- b. Moderately Deviant Articulation: Speech that receives one of the following accuracy scores:

4-year-old children	68.0-80.5%
4½-year-old children	79.0-85.0%

- c. Severely Deviant Articulation: Speech that receives one of the following accuracy scores:

4-year-old children	0.00-67.5%
4½-year-old children	0.00-78.5%

Interpretation of the Arizona Articulation Proficiency Scale: Revised in percent is as follows:

Score Range	Interpretation
95.0 to 100.0	Sound errors are occasionally noticed in continuous speech.
85.0 to 94.5	Speech is intelligible although noticeably in error.
70.0 to 84.5	Speech is intelligible with careful listening.
60.0 to 69.5	Speech intelligibility is difficult.
45.0 to 59.5	Speech usually is unintelligible.
0.0 to 44.5	Speech is unintelligible.

(Fudala, 1970)

Central Nervous System (CNS)

This is the part of the nervous system which comprises the brain and spinal cord (Zemlin, 1981).

Diadochokinesis

This refers to the ability to make rapid alternating speech and non-speech movements such as elevation and depression of the tongue, including production of single and multi-syllable verbalizations (Dworkin and Culatta, 1980a).

Dworkin-Culatta Oral Mechanism Examination (D-COME)

This is a clinical procedure for examining the structure and function of the oral mechanism, the results of which are derived from examiner judgments of normality (Dworkin and Culatta, 1980a).

Non-linguistic Tongue Function

Non-linguistic tongue function refers to functions of the tongue which are performed for purposes other than speech, such as swallowing or tongue clicking (Mason, 1980).

Normal Receptive Vocabulary

In this research, receptive vocabulary which is "normal" includes scores not greater than seven standard errors of measurement below the standard score equivalent on the Peabody Picture Vocabulary Test-Revised, (Dunn and Dunn, 1981). This includes scores received at or above the twenty-fifth percentile.

Oral Mechanism Examination

In the literature, the terms "oral mechanism examination," "oral peripheral examination," and "orofacial examination" are used interchangeably when referring to an evaluation of the speech structures. For the purposes of this research, the term "oral mechanism examination" was used to denote such an evaluation.

Peabody Picture Vocabulary Test-Revised (PPVT-R)

This is a tool designed to measure vocabulary recognition. The subject is required to respond to a single word stimulus by pointing to one of four pictures on a page. Although the PPVT-R is not an intelligence

test, it was used to measure normal receptive vocabulary and thus provide an indicator of normal or abnormal intelligence (Dunn and Dunn, 1981).

Screening

Screening is a testing procedure to identify, as quickly and economically as possible, individuals who are in need of a special service, such as those individuals who may have a hearing impairment (Katz, 1978). In this research, screening tests were administered to each child to determine whether or not he was to be included in the study. Pass/fail criterion for the standardized Peabody Picture Vocabulary Test-Revised was a score at the twenty-fifth percentile or higher to pass and a score of lower than the twenty-fifth percentile to fail. Pass/fail criterion for the hearing screening required that the subject respond to each tone presented at 25dBHL to pass, or not respond to one or more of the tones to fail (Katz, 1978).

Speech-Language Pathologist

"Speech-language pathologist" and "speech-language specialist" are used interchangeably. In this research, however, the term "speech-language pathologist" was used to denote one who has the Certificate of Clinical Competence in speech-language pathology issued by the American Speech-Language-Hearing Association and who works outside the school system. "Speech-language specialist" was used to denote one who may have only the State of California Clinical Rehabilitative Services Credential and who works in the school system.

CHAPTER TWO

REVIEW OF THE LITERATURE

Articulation disorders are the most frequently encountered of all the speech disorders, comprising over 75% of all speech problems (Travis, 1971; Van Riper, 1972). Articulation disorders are divided into two categories--organic and non-organic. The organic disorders may stem from "the neurophysiological inability of the child to produce the phonological units in the normal speech continuum" (Berry, 1980). Some causes of these disorders include: (1) A CNS injury as in cerebral palsy, (2) anatomical abnormalities as in cleft palate, (3) Temporal coding anomalies reflected in deficits in the neuromotor equipment necessary to produce phonemic clusters within a time frame, and (4) Psychoemotional disturbances blocking perceptual-motor integration of language (Berry, 1980).

Non-organic or functional disorders are the most common phonological deviations.² Dworkin (1979) cites the National Institute of Neurological Diseases and Strokes (1970) as stating that, of the 2.5 million children and young adults in the United States with a communication problem, 60% have a functional articulation disorder for which no psychologic or physical cause can be found. These disorders are very similar to those that appear in the normal speech development of children. Berry (1980) defines

²In the literature, the terms "functional" and "non-organic" are used interchangeably when referring to articulation disorders which are not organically based. Since "functional" is used in a different context in this research, the term "non-organic" will be used to denote such articulation.

them as the inability to phonologically produce the correct sounds, persisting in time past the normal speech development of children (Berry, 1980).

While the etiology of organic articulation disorders has been investigated to a great extent, only recently have non-organic disorders received attention from researchers. These non-organic articulation disorders merit study and investigation, "not only because they are so common but also because they are by no means so simply explained and treated as many people have assumed" (Travis, 1971). Travis goes on to say that too many cases are labeled non-organic by "diagnosis through default," that is, on the assumption that the speech defect must be non-organic if there are no obvious organic deviations to account for it.

The two basic evaluations made in an oral mechanism examination are the structural integrity--a "description of the shape, size, and relationship of the speech-production structures"--and the functional integrity--a determination of "the adequacy of the system for speech-related movements" (Peterson and Marquardt, 1981). The majority of research on the oral mechanism has been regarding lingual function. Johnson, et. al. (1963) state that deviations of oral structures cannot usually be related to specific deviations of speech. Their justification for performing an oral mechanism examination is that examining the structure provides an indication of its functional adequacy. If the client's oral motor abilities are within normal range, structural irregularities are not

significant (Johnson, et. al., 1963). The tongue has been cited as "one of the most important" oral structures in speech (Johnson, et. al., 1963) and is also noted to be the most adaptable organ of the oral mechanism (Mason, 1980).

When dealing with a person who has misarticulations, the speech-language pathologist does not begin to work immediately on correcting his speech. Instead, she investigates the individual's history and coexisting factors for an indication of why the speech sounds have not been mastered (Van Riper, 1972). The routine procedure for diagnosing an articulation disorder includes reviewing the case history, testing the articulation, language, hearing and perception, and performing an oral mechanism examination (Johnson, et. al., 1963). The speech-language pathologist often does not have a clear understanding of what she should look for and what she may find during an oral mechanism examination. She must make systematic observations based on experience and understanding of the task performance (Peterson and Marquardt, 1981). Since oral mechanisms are variable even in the normal population, she must perform examinations on several patients before she has a background from which to draw conclusions and report them (Emerick and Hatten, 1979). Descriptions included in test manuals of oral mechanism examinations are not sufficient for self-teaching of examination and rating techniques (Johnson, et. al., 1963).

While many authors and researchers have published oral mechanism examinations, they do not include specific explanations of how and when

to administer and how to score them.. These examinations consist basically of a checklist for structure and function of the oral mechanism. While a checklist is assumed to be sufficient for the "experienced" speech-language pathologist, the neophyte needs to have more specific information clarifying techniques for administering the examination and for determining what is normal or deviant. She must establish a frame of reference for the range of structural and functional variation (Emerick and Hatten, 1979). Even though she receives suggestions and advice from an experienced speech-language pathologist, this does not ensure that she will learn correctly or that she will remember the proper procedures. Without specific results, reporting conclusions may be inconsistent and subjective.

Similar to speech pathologists, professionals in other fields must learn basic procedural steps before tailoring them to meet their needs. For instance, audiological procedures are geared toward determining the specific anatomical and functional integrity of the hearing mechanism (Peterson and Marquardt, 1981). Once an audiologist is familiar with standard procedure and reporting format, a simplified form may meet his/her scoring and reporting requirements. In the same way the speech-language pathologist must learn the procedures before she can follow an abbreviated checklist.

ORAL MECHANISM EXAMINATIONS

Johnson, et. al. (1963) have developed an oral mechanism examination

which is often used by other authors as a basis for their oral mechanism evaluations. This examination form includes a checklist in which lingual structure and function are rated on a four-point scale from normal to extreme deviation. Clients are given three trials to perform adequately on the function portion of the examination. Tasks presented are not described in detail; however, a general description of the lingual structure and function is given with overall averages for diadochokinetic rates, touching corners of the mouth and touching the alveolar ridge. A summary section of the entire examination requests that the speech-language pathologist relate deviations found to the examinee's speech and take these deviations into account when planning a remedial program.

Darley, Aronson, and Brown (1975) consider the motor speech examination inseparable from the general neurologic examination. They divide the examination into two parts: (1) testing the motor speech and coordination of the peripheral speech mechanism during nonspeech activity, and (2) listening to the patient's motor speech for description and analysis, as well as for correlation with the neurologic findings. Darley, et. al. (1975) recommend following a checklist to avoid omitting important procedures and observations.

In describing the evaluation procedure for the hearing-impaired child, Ling (1976) requests that an oral mechanism examination be performed. He justifies this by stating that structural deficiencies and/or inadequate function of an organ complicate the task of teaching the hearing-impaired child. A summary of the oral mechanism examination is presented in which

items are to be checked if normal and described if abnormal. While a short summary and description of the diadochokinetic rate is given, no other procedures are described to assist the clinician in separating normal from abnormal. Instead, Ling suggests using the procedures proposed by Johnson, et. al. in 1963.

Riley (1976) incorporates some oral motor tasks in his Riley Motor Problems Inventory. These tasks include producing (puh) and (puh-tuh-kuh), and performing a tongue laterality task. Performance criteria for these include completeness, smoothness, sustainability, and rate. A short checklist of possible deviant behaviors is given for each task. A score of zero (0) is recorded for no deviant behaviors, with a score of two (2) recorded for one or more deviant behaviors. The total score can be compared to normative data accompanying the Riley Motor Problems Inventory.

In 1977, Nation and Aram published an oral mechanism examination which includes a four-point scale for rating structure and function in regard to each factor's possible adverse effects on speech. The lingual portion includes structure and function items with such tasks as protrusion, elevation, diadochokinetic rate and a check for tongue thrust pattern.

Dworkin (1978c) firmly states that the speech-language pathologist must be able to describe and classify motor speech disorders that affect the activities of the speech mechanism. He outlines examination procedures for differential appraisal of individuals suspected of having a motor speech impairment and includes summary charts describing speech mechanism

abnormalities which are associated with certain neurologic and non-neurologic conditions. Procedures for examination of the tongue include a general survey and assessment of lingual mobility, protrusion, elevation, strength, and diadochokinetic rate. These items are descriptive; however, the majority of the examination is judged subjectively.

Emerick and Hatten (1979) provide questions about each of the oral mechanism structures in outline form to use as a guide for conducting examinations. They recommend examining as many normal-speaking persons as possible to perfect one's techniques and observational skills as well as to establish a frame of reference on the range of structure and function. No scoring system is included; instead, writing a short narrative summary is suggested. Emerick and Hatten list several other authors to consult for further information on the oral mechanism.

The oral mechanism examination written by Hutchinson, Hanson, and Meham (1979) consists of a checklist with a three-point scale for rating test items. These researchers also provide a short descriptive summary of the tongue structure and function, including norms for diadochokinetic rate in five-, six-, and seven-year-old children. They suggest that an oral mechanism examination be administered as part of any speech-language examination but that a "motor examination" (including diadochokinetic rate, palatal movement, and gag reflex) be given only if the speech-language pathologist suspects neurological or muscular impairment.

In the tongue portion of their oral mechanism checklist, Mason and Simon (1980) include sections measuring size, diadochokinetic rate,

lingual frenum and general notations, to be checked as "normal" or "abnormal." Short notations regarding each area are included on the form to assist the examiner while she is performing the evaluation. An accompanying description by Mason (1980) explains in more detail the important areas to look at and what general proportions or patterns to look for. While Mason and Simon find little evidence to show that tongue movements for speech and non-speech activities are related, they advocate testing lingual function for some indication of nerve function and neuromotor maturation.

Dworkin and Culatta (1980a) have published an examination checklist in which they consider the oral mechanism examination one component of a comprehensive test battery. On the lingual subtest, specific materials, instructions, and examiner behaviors are listed for each structure or function to be assessed. The tasks are explained adequately and observations to be recorded for each item are included under examiner behaviors. The subject's performance on the tasks are generally rated "normal" or "abnormal," though specific descriptions of what is acceptable and what is unacceptable are limited. Abnormalities in test results may be compared to an error profile to assist diagnosis of a motor speech disorder such as spastic dysarthria.

Peterson and Marquardt (1981) state that the purpose of the oral mechanism examination is to "describe the status and function of the articulatory and resonatory systems." They advocate including this examination as an integral part of the speech-language evaluation and

carrying it out systematically and efficiently. These researchers employ an overall judgment technique for screening structure, and syllable diadochokinesis for screening function, using procedures established by Johnson, et. al. (1963). If the client shows no significant deviations in either area, the evaluation is to be discontinued. Should questions or deviations arise, an additional checklist for the oral mechanism examination is to be used. Peterson and Marquardt only briefly review the procedures for the evaluation. Procedural descriptions are written to be representative, not exhaustive; reference to various authors (Darley, et. al., 1975; Mason, 1969; Mason and Simon, 1977; Dworkin, 1978c) is made for further detail.

In summary, most researchers provide a checklist for the examiner to follow but do not recommend check-marking through the steps of the examination. They suggest only that one follow the checklist as a procedural guide, based on one's experience, and record observations of significance separately. Difference of opinion exists as to whether this examination should be a routine part of the speech-language evaluation; all agree that suspicion of a neurological or muscular disorder warrants an oral mechanism examination. Review of the protocols presented indicates the need for continued modification of the oral mechanism examination.

NORMATIVE DATA

According to Hutchinson, et. al. (1979), during the first years of speech-language pathology research, interest arose in obtaining norms of

the structure and function of the speech mechanism. They noted, however, that researchers lost enthusiasm before such complete information was obtained, and only recently has new interest been shown in establishing normative data.

Darley, et. al. (1975) used an 11-point scale for rating muscular impairment. Nation and Aram (1977), on the other hand, advocate describing the client's oral musculature on a four-point scale; Hutchinson, et. al. (1979) suggest a three-point scale. Speech-language pathologists need to obtain the following information:

1. Normative data on specific motor speech tasks which can be accomplished successfully by people at each year of life from early childhood to adulthood.
2. Norms on speech tasks which correlate with articulation for individuals throughout the same span of years (Hutchinson, et. al., 1979).

These researchers justify the need for more exact data by citing an example involving Robinson (1973). Previous guidelines for cerebral palsy children stated that "phonation must be sustained for ten seconds before speech therapy should be initiated" (Westlake, 1951). However, Robinson's research has established the fact that even normal children cannot meet this requirement (Hutchinson, et. al., 1979).

Several attempts have been made to norm diadochokinetic rates for children four years of age through adults. Single syllable rates range from one per second (Emerick and Hatten, 1979) to 6.2 per second (Dworkin and Culatta, 1980a); three-syllable sequences range from eight in ten seconds (Hutchinson, et. al., 1979) to 17.5 in ten seconds (Sprague,

1961). Most norms stated are for children six years of age and older (Bloomquist, 1950; Lundeen, 1950; Fairbanks and Spriestersbach, 1950; Irwin and Becklund, 1953; Johnson, et. al., 1963; Fletcher, 1972; Riley, 1976; Dworkin, 1978c; Emerick and Hatten, 1979; Hutchinson, et. al., 1979; Dworkin and Culatta, 1980a).

Hutchinson, et. al. (1979) postulate that the main reason research has not found a strong correlation between diadochokinetic tasks and articulation in the past is because many diadochokinetic tasks "require repetitions of the same movements" while speaking requires repetition of rapidly changing sequences of movements. The rapid sequencing of different phonemes appears more relevant in evaluating speech and should be included when comparing diadochokinesis to articulation (Hutchinson, et. al., 1979).

PREVIOUS ATTEMPTS AT OBJECTIVE LINGUAL MEASUREMENTS

Lingual Structure

Authors include little descriptive explanation of how to examine the lingual structure. No standardized method of measuring lingual size or volume accurately exists due to the tongue's adaptive nature; only the relative size can be estimated (Bandy and Hunter, 1969; Mason, 1980). Several researchers agree that the position of the individual's tongue should first be examined at rest. The tip normally lies just below the edges of the mandibular incisors with the surface visible above the

teeth in all areas of the mouth. At rest, the normal tongue exhibits very little, if any, intrinsic muscle activity (Dworkin, 1978c, Hutchinson, et. al., 1979; Dworkin and Culatta, 1980a). Mason (1980) suggests that the speech-language pathologist have the individual bite down and, if the teeth approximate without biting the tongue, the tongue size is within normal limits.

Lingual Function

Dworkin (1980) cites several researchers who state that articulatory movements must be coordinated in time and in intensity of movement to achieve normal articulation. Most lingual function research has centered around these two aspects.

Diadochokinetic Rate: A measure of diadochokinetic rate is routinely included in an oral mechanism examination (Johnson, et. al., 1963). An estimation of the neuromotor maturation for speech can be found from lingual diadochokinetic testing (Mason, 1980). Diadochokinetic rates are typically determined by asking the individual to produce single syllables such as (puh), (tuh), or (kuh) and syllable series varying from (duh-guh) to (puh-tuh-kuh) to (dippity-dippity-doo) as quickly as possible for a specific amount of time (Bloomquist, 1950; Lundeen, 1950; Fairbanks and Spriestersbach, 1950; Irwin and Becklund, 1953; Johnson, et. al., 1963; Fletcher, 1972; Riley, 1976; Dworkin, 1978c; Emerick and Hatten, 1979; Hutchinson, et. al., 1979; Dworkin and Culatta, 1980a).

When Irwin and Becklund (1953) established diadochokinetic norms, they used an electro-acoustic apparatus on which the examiner could take

a reading of the speaker's performance as he was producing the syllables. The mean rates were in agreement with other researchers, indicating reliability.

Instead of using the traditional count-by-time procedure (measuring the time and counting the syllables produced within the time), Fletcher (1972) used the time-by-count strategy and found reliable norms. In this procedure, the speech-language pathologist starts the stop watch when the speaker begins to repeat the syllables and counts the syllables as they are produced. When the required number of repetitions are completed, the stop watch is turned off and the time recorded.

Researchers have begun placing less emphasis on the quantity of the syllables and more emphasis on the quality (Fletcher, 1972; Mason and Simon, 1980). Mason and Simon state that "the examiner should focus on the pattern of the tongue movement and the consistency of the contacts made, rather than counting repetitions per second."

Lingual Strength: Researchers are reported to have measured tongue strength with mercury manometers and lever scale devices as early as 1889 (Palmer and Osborn, 1940; Darley, Aronson, and Mulder, 1980). In 1940 Palmer and Osborn measured tongue strength by placing a rubber ball attached to a mercury manometer on the dorsum of the tongue and asking the subject to press the ball as hard as possible against the hard palate. Lever scale devices or strain gauges have been used by other researchers (Fairbanks and Bebout, 1950; Kydd, 1956; Kydd, 1957; Winders, 1958; Saunders and Perlstein, 1965). More recently, researchers such as

Christiansen, Evans, and Sue (1979) have experimented with a strain-gauge transducer to measure the resting lingual forces. Using three sizes of sensors to measure the resting lingual forces resulted in increased forces as the transducer decreased tongue width.

Dworkin (1978a; 1979; 1980) experimented with a lever scale apparatus constructed of lucite with forehead and chin stabilizers. This instrument, which works on the principle of coil-spring resistance, required that the subject push his tongue against the mouthpiece rod so that a reading could be taken. This scale provided an estimate, in grams, of the protrusive lingual force of the tongue while isolating all other muscles.

Following Dworkin's studies, Dworkin, Aronson, and Mulder (1980) used a custom-designed miniature force transducer connected to a pen-writing ECG recording system. When a subject bit down on the stem of the force transducer and applied pressure with his tongue, the force was recorded. The researchers found this transducer to be useful and recommend that it be used in diagnosing neurologic and other severe disorders, in quantifying tongue strength in dysarthrias, or documenting progress in tongue strength.

Other Oral Motor Abilities: Little research has investigated other oral motor abilities. Since the tongue is so adaptive, only relative estimates are made (Mason, 1980). With oral motor abilities so difficult to quantify, they have not been conclusively shown to correlate with speaking ability (Shelton, Arndt, Krueger, and Huffman, 1966).

NON-LINGUISTIC TONGUE FUNCTION CORRELATED TO ARTICULATORY COMPETENCE

Motor Abilities

Early researchers have described children with articulation problems as having a "slow" or "lazy" tongue (Van Riper, 1972). Studies of general coordination and gross motor abilities in conjunction with speech disorders have been found to have conflicting results (Dworkin, 1979). Some studies (Reid, 1947; Fairbanks and Bebout, 1950; Fairbanks and Spriestersbach, 1950; Everhart, 1953) have concluded that there are no significant differences in measurements of physical structure and motor coordination between speech-disoriented and normal groups. Other studies, however, suggest that the consistency in patterns of action indicates that motor abilities are stronger for speech defective children than for control groups (Bilto, 1941; Albright, 1948; Jenkins and Lohr, 1964).

Oral Motor Tasks

Oral motor tasks and non-linguistic tongue function are more directly related to the oral mechanism than general motor abilities, and thus have a more direct effect on speech. Although Shelton, et. al. (1966) were not able to delineate children with inferior articulation from observation of non-speech movements of the speech mechanism, a literature review by Dworkin (1979) revealed that many non-organic articulatory defects, particularly lispings, are due to "a muscularly weak and poorly

coordinated tongue." Defects of lingual weakness and dysdiadochokinesia have most frequently been investigated in correlation with individuals who have non-organic disorders (Dworkin, 1980).

Diadochokinetic Rate: When contrasting diadochokinetic rates as well as other facial movements, in young adults with superior or inferior articulation, Fairbanks and Spriestersbach (1950) reported only a slightly higher motor ability in the superior articulation group, although males performed better in some tasks, such as tongue protrusion and tongue-alveolar movement. A study of diadochokinetics by Lundeen (1950) also found males performed better but, more importantly, that diadochokinetic rate was more rapid for commonly used neuromuscular patterns, such as syllable production. Also, syllable speed was progressively faster the more common the pattern, and speed increased in relative order of sound acquisition. Articulation cases were observed to produce a newly learned sound slower and to have more difficulty incorporating it into conversation than those who could produce the newly learned sound at a relatively fast rate (Lundeen, 1950). Yoss and Darley (1974) experimented with diadochokinesis and found the mean rates for the defective speaking group to be significantly lower than those rates for the control group.

Lingual Strength: In 1940, Palmer and Osborn compared tongue pressures between speech defective and control groups and concluded that speech defective individuals, in general, have "a low muscular strength of the tongue." Although some individuals who stuttered or had other types of speech defects had low tongue strength, the individuals who

had poor articulation showed the lowest muscular strength. Other studies involving groups of lisping and control subjects (Subteley, Mestre, and Subteley, 1964; Weinberg, 1968; McGlone and Proffit, 1973) have also reported that tongue coordination and strength are significantly lower in individuals who lisp.

More recently, Dworkin (1978a) compared normal with lisping speakers and found normal speakers to score significantly higher on both lingual force and on diadochokinetic measurements. Two more studies by Dworkin (1979; 1980) also showed children with frontal lisps to have significantly reduced tongue strength in comparison with the normal children. Dworkin's studies conclude that speech-language pathologists should assess these factors during evaluations and that lingual muscular training may be a prerequisite to articulatory improvement in frontal lisps (Dworkin, 1978a, 1979; 1980).

When Dworkin and Culatta (1980b) studied protrusive lingual strength in children with normal versus tongue thrust swallowing and normal versus deviant articulation, they found no significant difference between children with anterior tongue thrusting during swallow and children who did not demonstrate a tongue thrust. In addition, children with frontal lisps were not found to have significantly weaker tongues than children without lisps (Dworkin and Culatta, 1980b).

SUMMARY

In summary, a review of the literature indicates that an oral mechanism examination is a routine part of an articulation evaluation. Neither the examination manuals nor the literature include a conclusively objective explanation of how to administer and score such examinations. Also, it appears that there is some correlation between lingual function and articulatory competence; however, conflicting and inconclusive studies indicate the need for additional research.

CHAPTER THREE

RESEARCH DESIGN AND PROCEDURES

A correlation design was used in the present pilot study. Twenty-four children served as subjects for this research. Each child was categorized into one of three diagnostic groups: (1) "normal" articulation ability, (2) "moderate" articulation problem, or (3) "severe" articulation defect. Eight children were selected to fit into each group. Each subject's lingual structure and function were measured using a researcher-developed protocol based primarily on the Evaluation of Tongue subtest from the Dworkin-Culatta Oral Mechanism Examination (Appendix A).

POPULATION AND SAMPLE

The children who participated in this study were preschoolers between the ages of four years, zero months and four years, eleven months who were attending some type of preschool program. All subjects were selected from preschools in the Riverside, California community, which is not unlike many other communities in the United States.

The subjects to be studied were referred by the school speech-language specialist who was briefed on the three articulation categories by referring to the descriptive interpretation of the scoring system for the Arizona Articulation Proficiency Scale: Revised. The speech-language specialist selected subjects considered suitable for each of the categories and recommended placement. If the school had no speech-language specialist,

the preschool teacher selected subjects whom she felt would fit into these categories and recommended placement.

Since this research investigated children who had no organic abnormalities which might impair speech, the subjects with obvious organic problems such as cerebral palsy were screened from the research population to avoid biasing the data. The researcher determined this by selecting children with "moderate" or "severe" articulation problems who had only a developmental delay, characterized by immature speech, typical of a child at a younger age.

METHODOLOGY

This investigation was a pilot study involving development of a protocol based on the Examination of Tongue subtest from the Dworkin-Culatta Oral Mechanism Examination (D-COME). The D-COME is a clinical examination procedure, the results of which are derived from the examiner's judgments of normality (Dworkin and Culatta, 1980a). The Examination of Tongue subtest was studied in detail, and a protocol was developed for evaluating the items more objectively, emphasizing lingual strength and diadochokinesis.

Measurements which have been normed or definitions which were available in the literature were used for the tasks presented in the protocol. The items in each of these tasks were to be checked as "normal" or "abnormal" and were specifically defined. The tasks presented in the protocol which did not have normed measurements or objective definitions

were scored using objective data. When the protocol was written, three certified speech-language pathologists reviewed its contents for completeness and objectivity, and the researcher made any necessary revisions before testing subjects with it.

The initial screening procedures determined that each subject had hearing within normal range and had normal receptive vocabulary. Hearing screening involved having each subject individually seated at a table beside the examiner in a quiet room. The subject's hearing was screened at a 25dBHL level for the pure tone frequencies of 500, 1000, 2000, and 4000 Hz with an audiometer calibrated to ANSI standards. The subject was instructed that he would be wearing earphones through which he would hear sounds, first in one ear and then in the other. He was told to raise his hand when he heard a sound and put his hand down when the sound stopped. Once the subject demonstrated that he understood the task, the testing began. If the subject failed to respond to one or more of the sounds, he failed the hearing screening. If the subject passed the screening, his receptive vocabulary was screened with the Peabody Picture Vocabulary Test-Revised, administered according to the test manual. Each child was required to pass this vocabulary test at the twenty-fifth percentile or higher for his age.

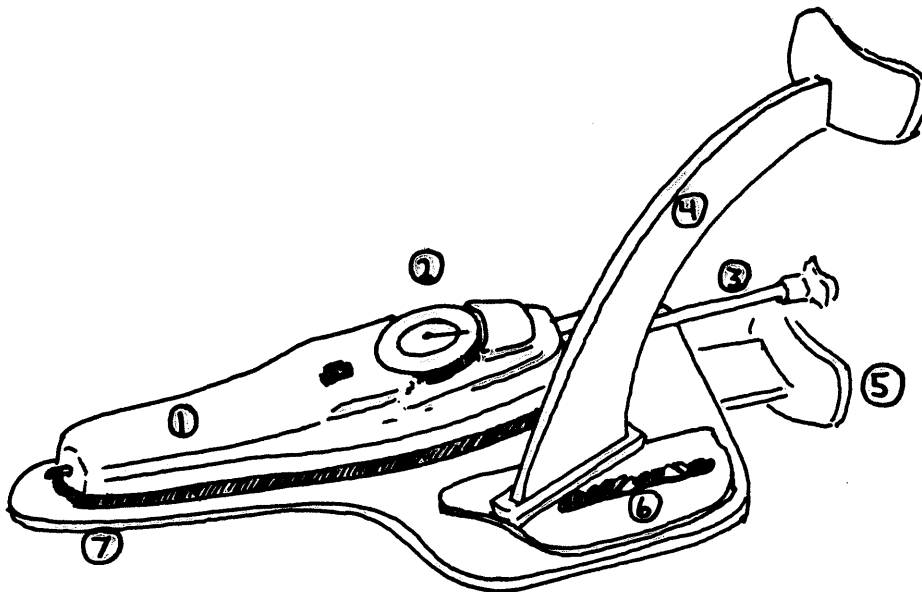
Children who met both of these qualifications were then tested for placement into a "normal," "moderate" or "severe" articulation category using the Arizona Articulation Proficiency Scale: Revised. Each child was tested, according to the test manual, and the first eight subjects to

qualify for each category participated in this study.

A strain gauge assembly for measuring lingual strength was constructed for a portion of the protocol. This assembly was designed to measure anterior and lateral protrusive lingual force from a stable position. The examiner could hold the strain gauge assembly in her hands or could rest it on a table to maintain a stable position (See Figures 1 and 2). Each subject was tested while his head was resting firmly on the forehead brace (#4) and the chin brace (#5), with his jaw relaxed and his mouth slightly open. The braces could be adjusted shorter or longer for each individual by sliding screws to different notches near the body of the gauge (#6 & #7). For anterior lingual strength measurement, each subject was requested to place his tongue tip against the tip of the gauge extension arm (#3) and push, using maximum strength. For lateral lingual strength measurement, each subject was requested to place his tongue tip against the inside of his cheek and push, using maximum strength. As the subject pushed, a reading of the maximum strength was recorded from the gauge reading dial (#2).

When the subjects for the study had been selected, they were numbered from one through twenty-four so that they remained anonymous. Two children from each category were randomly selected. The researcher and a speech-language specialist assessed these children's lingual structure and function, following the developed protocol, to verify interjudge reliability. Once interjudge reliability had been established, the researcher assessed the remaining sixteen children following the protocol. During

Figure 1
STRAIN GAUGE ASSEMBLY
view from above



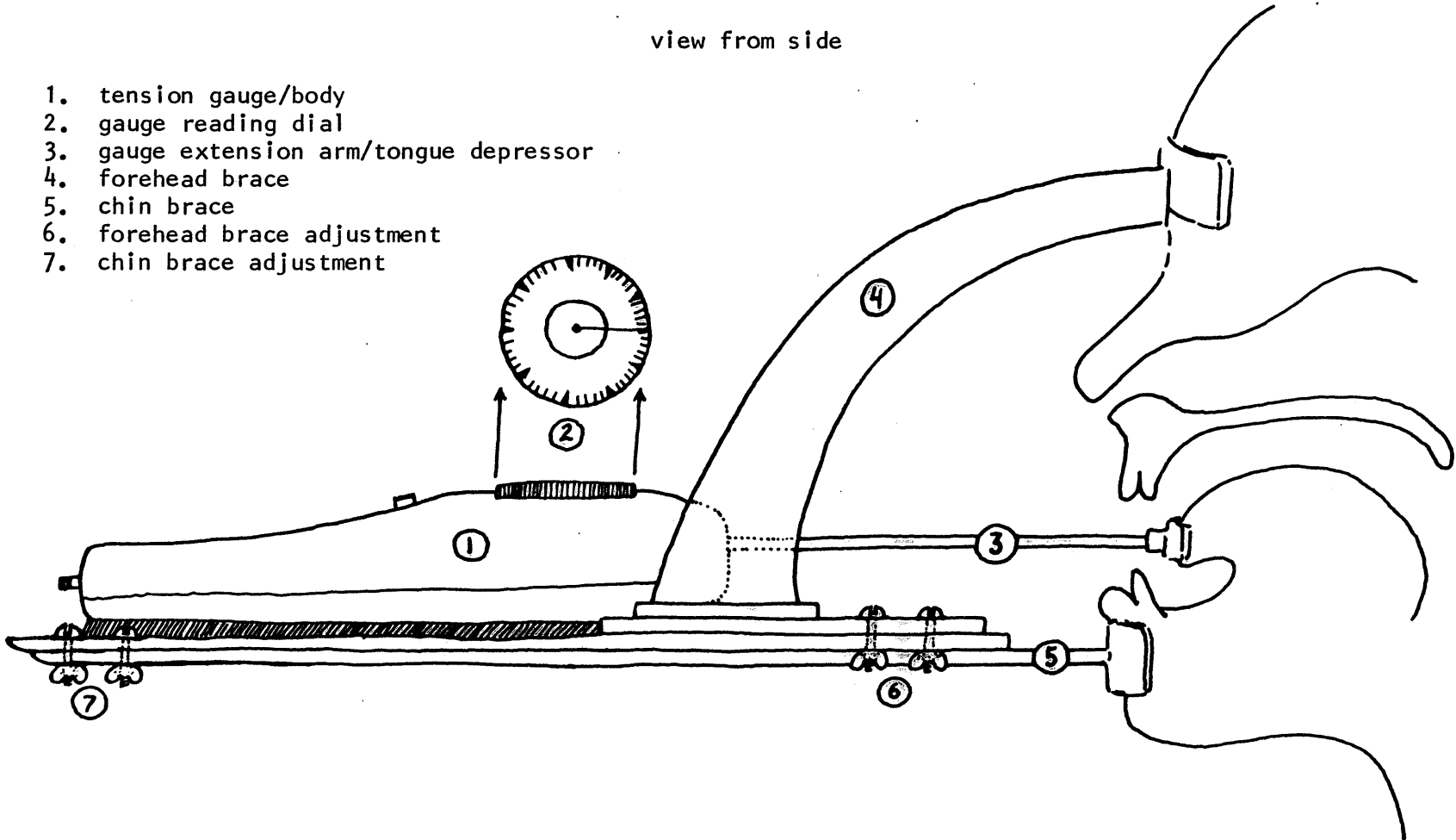
1. tension gauge/body
2. gauge reading dial
3. gauge extension arm/tongue depressor
4. forehead brace
5. chin brace
6. forehead brace adjustment
7. chin brace adjustment

Figure 2

STRAIN GAUGE ASSEMBLY

view from side

1. tension gauge/body
2. gauge reading dial
3. gauge extension arm/tongue depressor
4. forehead brace
5. chin brace
6. forehead brace adjustment
7. chin brace adjustment



assessment of the children, the researcher photographed typical normal and abnormal structure and made video and voice tapes of typical normal and abnormal function for each task presented in the study. This information was intended to accompany the protocol to more objectively define examination specifications for use by other clinicians in the future. However, this was not completed because the researcher was not able to obtain samples of "normal" and "abnormal" for each task presented. The obtained samples were to be used for instructional purposes in university courses.

CHAPTER FOUR

RESULTS

A protocol was developed for the examination of the tongue and assessment of each subject followed this protocol (Appendix A). Twenty-four children between the ages of four years, zero months and four years eleven months, who were selected from six preschools in the Riverside, California area, were divided into three groups of eight children each. Group 1 subjects had "normal" articulation, Group 2 subjects had "moderate" articulatory deviations, and Group 3 subjects had "severe" articulatory deviations. As shown in Table 1, 16 of the subjects (66.7%) were males and 8 of the subjects (33.3%) were females. Seventeen (71%) of the subjects were Caucasian; seven (29%) of the subjects were minority students (Blacks and Mexican-American children).

The lingual examination, consisting of 30 tasks, was administered to determine if significant differences existed between the three groups. Twenty-two tasks presented which had normed measurements or definitions stated in the literature were recorded as "normal" or "abnormal." Eight tasks presented which did not have normed measurements or objective definitions were recorded using objective data. Results of the examinations are presented in Tables II and III.

The null hypothesis stated that "no statistically significant relationship exists between performance on the lingual structure and function test and the subject's articulatory competence." A Chi Square

test for homogeneity indicated that, of 22 tasks performed, one task was significant. That item, which tested diadochokinetics using sequential syllables, was significant at the .05 level. The Kruskal-Wallis test was applied to the remaining eight tasks and indicated no significant difference on any of the tasks at the .05 level. This finding, that 29 of the 30 tasks were not significant, fails to reject the null hypothesis, and indicates that very little relationship exists between lingual structure and function, and articulatory competence.

TABLE I
A DESCRIPTION OF THE SAMPLE BY AGE, SEX, AND ETHNIC GROUP
ACCORDING TO LEVEL OF ARTICULATION

SEVERE

AGE	CAUCASIAN		BLACK		MEXICAN-AMERICAN	
	female	male	female	male	female	male
4.0-4.5	0	1	0	0	0	0
4.5-5.0	1	5	0	1	0	0
Total	1	6	0	1	0	0

MODERATE

AGE	CAUCASIAN		BLACK		MEXICAN-AMERICAN	
	female	male	female	male	female	male
4.0-4.5	1	1	0	1	0	0
4.5-5.0	1	2	0	0	0	2
Total	2	3	0	1	0	2

NORMAL

AGE	CAUCASIAN		BLACK		MEXICAN-AMERICAN	
	female	male	female	male	female	male
4.0-4.5	1	0	0	0	1	0
4.5-5.0	2	2	0	0	1	1
Total	3	2	0	0	2	1

TABLE II
RESULTS OF LINGUAL ABILITIES CATEGORIZED AS NORMAL OR ABNORMAL

Normed and Defined Tasks	Level of Articulation						P-value*
	NORMAL percent (number)		MODERATE percent (number)		SEVERE percent (number)		
1. General Survey							
a. Appearance							
normal	100	(8)	100	(8)	100	(8)	n.s.
abnormal	0	(0)	0	(0)	0	(0)	
b. Tongue at rest							
normal	100	(8)	100	(8)	100	(8)	n.s.
abnormal	0	(0)	0	(0)	0	(0)	
c. Size							
normal	100	(8)	100	(8)	87.5	(7)	n.s.
abnormal	0	(0)	0	(0)	12.5	(1)	
d. Surface							
normal	87.5	(7)	100	(8)	100	(8)	n.s.
abnormal	12.5	(1)	0	(0)	0	(0)	
2. Passive Tongue Mobility							
a. Mobility							
normal	100	(8)	100	(8)	100	(8)	n.s.
abnormal	0	(0)	0	(0)	0	(0)	
3. Tongue Protrusion							
a. Symmetry							
normal	100	(8)	100	(8)	100	(8)	n.s.
abnormal	0	(0)	0	(0)	0	(0)	
b. Tongue Protrusion**							
4. Active Tongue Mobility							
a. Speed**							
b. Range							
normal	75	(6)	100	(8)	100	(8)	n.s.
abnormal	25	(2)	0	(0)	0	(0)	
c. Movement							
normal	75	(6)	100	(8)	100	(8)	n.s.
abnormal	25	(2)	0	(0)	0	(0)	
5. Tongue Elevation							
a. Range							
normal	75	(6)	87.5	(7)	87.5	(7)	n.s.
abnormal	25	(2)	12.5	(1)	12.5	(1)	
b. Frenum							
normal	100	(8)	100	(8)	87.5	(7)	n.s.
abnormal	0	(0)	0	(0)	12.5	(1)	
6. Anterior Tongue Strength							
a. Strength**							
7. Lateral Tongue Strength							
a. Right Side Strength**							
b. Left Side Strength**							

TABLE II (continued)

Normed and Defined Tasks		Level of Articulation						P-value
		NORMAL percent (number)		MODERATE percent (number)		SEVERE percent (number)		
8. Lingual Diadochokinetics								
a. Syllable Production								
(tuh)	normal	100	(8)	100	(8)	100	(8)	n.s.
	abnormal	0	(0)	0	(0)	0	(0)	
(kuh)	normal	100	(8)	100	(8)	87.5	(7)	n.s.
	abnormal	0	(0)	0	(0)	12.5	(1)	
b. Rate								
(tuh)	normal	100	(8)	100	(8)	100	(8)	n.s.
	abnormal	0	(0)	0	(0)	0	(0)	
(kuh)	normal	100	(8)	100	(8)	100	(8)	n.s.
	abnormal	0	(0)	0	(0)	0	(0)	
c. Timing								
(tuh)	normal	100	(8)	87.5	(7)	100	(8)	n.s.
	abnormal	0	(0)	12.5	(1)	0	(0)	
(kuh)	normal	100	(8)	87.5	(7)	100	(8)	n.s.
	abnormal	0	(0)	12.5	(1)	0	(0)	
9. Sequential Syllable Rates								
a. Syllable Production								
(dip)	normal	87.5	(7)	50	(4)	25	(2)	s. at <.05
	abnormal	12.5	(1)	50	(4)	75	(6)	
(lip)	normal	50	(4)	12.5	(1)	37.5	(3)	n.s.
	abnormal	50	(4)	87.5	(7)	62.5	(5)	
(gip)	normal	25	(6)	25	(2)	50	(4)	n.s.
	abnormal	75	(2)	75	(6)	50	(4)	
b. Rate**								
c. Timing								
(dip)	normal	100	(8)	87.5	(7)	100	(8)	n.s.
	abnormal	0	(0)	12.5	(1)	0	(0)	
(lip)	normal	100	(8)	87.5	(7)	100	(8)	n.s.
	abnormal	0	(0)	12.5	(1)	0	(0)	
(gip)	normal	100	(8)	87.5	(7)	100	(8)	n.s.
	abnormal	0	(0)	12.5	(1)	0	(0)	

*Chi Square test for homogeneity

**Recorded in Table III as objective data

n.s. = not significant at <.05 level

s. at <.05 = significant at <.05 level

TABLE III
RESULTS OF LINGUAL ABILITIES RECORDED AS OBJECTIVE DATA

Objective Data	Level of Articulation			P-value*
	NORMAL median (range)	MODERATE median (range)	SEVERE median (range)	
3. Tongue Protrusion				
b. Length (in sixteenths of an inch)	14 (13-17)	12.5 (8-16)	14.5 (12-17)	n.s.
4. Active Tongue Mobility				
a. Speed (number of cycles in three sec)	3 (1-7)	4 (2-6)	3.5 (2-6)	n.s.
6. Anterior Tongue Strength				
a. Strength (in hundredths of a gram)	.78 (.30-1.50)	.75 (.40-1.50)	.80 (.10-1.10)	n.s.
7. Lateral Tongue Strength				
a. Right side strength (in hundredths of a gram)	.40 (.20-.80)	.45 (0.0-1.65)	.38 (.15-.50)	n.s.
b. Left side strength (in hundredths of a gram)	.40 (0.0-.50)	.50 (0.0-.90)	.43 (.10-.80)	n.s.
9. Sequential Syllable Rates				
b. (dip) (number of times in five sec)	3 (2-4)	3 (1-6)	3 (2-4)	n.s.
(11p) (number of times in five sec)	3 (2-4)	2.5 (1-6)	3 (2-3)	n.s.
(gip) (number of times in five sec)	2.5 (2-5)	2.5 (2-6)	2.5 (2-3)	n.s.

*Kruskal-Wallis test for differences

n.s. = not significant at <.05 level

s. at <.05 = significant at <.05 level

CHAPTER FIVE

DISCUSSION

Review of the literature indicated that an oral mechanism examination had become an accepted part of a speech and language examination, without conclusive rationale or complete explanations for administration and scoring of such tests. Since the tongue is most important in speech production (Johnson, et. al., 1963), this research was limited to the study of lingual structure and function.

The present study found that lingual structure and function were significant on one of 30 tasks performed by children in the articulatory proficiency categories of "normal," "moderate," and "severe." These categories refer to levels of intelligibility as defined by the Arizona Articulation Proficiency Scale: Revised. The null hypothesis cannot be rejected because only the item testing diadochokinetics using sequential syllables was significantly lower for the "severely" deviant articulation category than for the other categories.

This indicates that little correlation exists between an individual's lingual structure and function and his articulatory proficiency. These findings are in disagreement with the majority of the past findings; however, many of the studies showing correlation between normal and deviant groups have compared lisping speakers to normal speakers. The present results are in harmony with Dworkin and Culatta's study (1980) in which children with poor articulation were not found to have significantly weaker tongues.

The present research, which found performance on a diadochokinetic task to be significantly different between the "severe" articulation group and the "normal" and "moderate" groups, is in accordance with the idea proposed by Hutchinson, et. al. (1979) that the rapid sequencing of different phonemes is more relevant in evaluating speech.

The findings of this study suggest, therefore, that diadochokinetic rate is the only portion of the oral mechanism examination that differentiates between groups of four-year-old children with non-organic articulation disorders and that performance of the remainder of the oral mechanism examination for this purpose must be questioned. It should be noted that this was proven true only for the group examined in this study. However, it appears unlikely, in view of the findings, that a study of older children would show any difference.

Research Limitations

The results of this research may have been influenced by certain factors. First, although the subjects were divided by articulatory competence, according to the Arizona Articulation Proficiency Scale: Revised, it was possible for very little difference to exist between the children in different categories. That is, a difference of one month in age or one additional sound in error could mean the difference in a category grouping for a subject. Consequently, some subjects may have been so similar that difference in lingual structure and function between categories was too minimal to show significance in lingual testing.

Another influencing factor, different from past studies, is the fact that this study divided subjects into groups of articulatory competence, whereas many studies in the past have compared lisping and control groups. Since this study categorized subjects according to "normal," "moderate" and "severe," lispers could be present in any or all of these groups. Thus, lisping speakers could have poor lingual structure and function as shown in previous studies, and they could have influenced each group equally without allowing the subjects having articulatory deviancy to show significant results.

Lingual measurements do not lend themselves well to objectivity. Many test items were scored by definition and may have some interjudge variability. What may appear normal to a particular speech-language pathologist may seem abnormal to another, depending on one's experience and frame of reference.

The object of taking pictures and making recordings of typical lingual structure and function during the oral mechanism examinations was to obtain samples for instructional purposes in future university courses. Unfortunately, it was not possible to complete this part of the research because using a sample of 24 children with normal hearing and language who had varying degrees of articulatory competence, "normal" and "abnormal" examples for each task were unobtainable. This is understandable given the sample size and the fact that the sample was not chosen for that purpose. Children in this study did not exhibit multiple "abnormal" characteristics because those with obvious organic problems

were screened from the research population.

Implications for Practice

This research suggests that there is minimal rationale for performing the lingual portion of the oral mechanism examination on a four-year-old child who has normal hearing and language but who has a non-organic articulation disorder. It may be beneficial for speech-language specialists who have limited time for evaluations to be aware of this. Of course, the results of past research, such as the studies indicating correlation between lisps and lingual strength, should be taken into consideration. In such instances, tongue strengthening exercises may be of value in therapy. Also, individual differences of each child should be considered.

Suggestions for Further Study

The results of this research indicate areas for further research:

- 1) repetition of the study, categorizing the subjects according to place, manner and voicing of articulation errors instead of by general articulatory competence;
- 2) repetition of the study, using a larger number of subjects because of the possibility that the researcher did not get a representative sample of the general population;
- 3) enlarging on a specific portion of the research, such as indepth lingual strength testing because there is a possibility of the study being contaminated by too many tasks due to the subject's fatigue or disinterest;

- 4) recording examples of typical lingual structure and function through pictures, video and voice tapes to be used for instructional purposes in administering the lingual portion of the oral mechanism examination.

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APPENDICES

APPENDIX A

EXAMINATION OF TONGUE STRUCTURE AND FUNCTION

1. GENERAL SURVEY

When the subject is asked to look straight at the examiner, open his mouth as wide as possible and rest the tip of his tongue just behind his lower front teeth, the examiner will evaluate the appearance of the tongue at rest (Dworkin and Culatta, 1980a). Check either (a) or (b) for each of the following signs:

- Aa. _____ normal appearance: no atrophy of the tongue tissue (Dworkin and Culatta, 1980a).
- Ab. _____ abnormal appearance: atrophy on the right or left side of the tongue which appears as a wasting or withering of the muscle tissue (Dworkin and Culatta, 1980a).
- Ba. _____ normal tongue at rest: if the subject rests his tongue-tip beyond the cutting edges of the lower incisors, slight, benign muscle twitching may occur. This activity should decrease, however, once the tongue-tip is repositioned behind the incisors (Dworkin and Culatta, 1980a).
- Bb. _____ abnormal tongue at rest: tongue has fasciculations which consist of involuntary contractions or fine twitchings of groups of muscle fibers when the tongue is at rest in the mouth (Dworkin and Culatta, 1980a). These are not to be confused with normal tremors, seen as rippling twitches of the tongue muscles when the subject protrudes his tongue (Hutchinson, et. al., 1979).
- Ca. _____ normal size: when the subject bites down, the teeth can approximate without biting the tongue (Mason, 1980).
- Cb. _____ abnormal size: microglossia which appears as the tongue being obviously smaller than an average tongue in relation to the mandible (Dworkin and Culatta, 1980).
- OR
- _____ macroglossia which appears when the tongue is at rest on the floor of the mouth and extends over the teeth, so that the subject cannot approximate his teeth

without biting his tongue (Mason, 1980).

- Da. _____ normal surface: no apparent growths, lesions or other physical addition to the overall appearance of the tongue (Dworkin and Culatta, 1980).
- Db. _____ abnormal surface: lesions apparent as pathological tissue due to injury, wound, or disease (Dorland, 1942).
- _____ abnormal surface: growths apparent as abnormal formations or masses of tissue attached to the tongue (Dorland, 1942).

2. PASSIVE TONGUE MOBILITY

When the subject is asked to "stick out" his tongue (Dworkin and Culatta, 1980a) and relax,¹ the examiner grasps the tip of the tongue with a piece of gauze positioned between the index finger and thumb and gently pulls the tongue upward and toward each side of the mouth (Dworkin and Culatta, 1980a). Check either (a) or (b) for the following signs:

- Aa. _____ normal mobility: the tongue moves without the examiner pulling effortfully on the tongue (Dworkin and Culatta, 1980a).
- Ab. _____ abnormal mobility: tongue has resistive activity so that mobility is reduced and tongue resists the examiner's pull (Dworkin and Culatta, 1980a).

3. TONGUE PROTRUSION

When the subject is asked to "stick his tongue straight out" (Dworkin and Culatta, 1980a) as far as it will go, the examiner holds a tongue depressor on the center of the lower lip and marks the maximum extension of the tongue on the tongue depressor.¹ Check either (a) or (b) for each of the following signs:

- Aa. _____ normal symmetry: the tongue protrudes straight out with no deviation to the right or left (Ratcliff, 1982).
- Ab. _____ abnormal symmetry: unilateral deviation in which the tongue deviates to the right or left side (Dworkin and Culatta, 1980a).

Record the following objective data:

- B. _____ tongue length to the nearest sixteenth of an inch.

4. ACTIVE TONGUE MOBILITY

When the subject is asked to "stick his tongue straight out and wiggle it from side to side as quickly as he can," and the examiner demonstrates by at least three seconds of tongue wiggling, the examiner will evaluate the active tongue mobility (Dworkin and Culatta, 1980a). Check either (a) or (b) for the following signs or record the following objective data:

- A. _____ speed: record the number of complete cycle of contacts performed for three seconds; a complete cycle includes touching both corners of the mouth with the tongue.
- Ba. _____ normal range: full excursion to corners of mouth, with the tongue not resting on lower lip (except in children under age six) (Riley, 1976).
- Bb. _____ abnormal range: reduced range so that the tongue does not reach the full excursion to the corners of the mouth (Riley, 1976).
- Ca. _____ normal movement: the tongue moves smoothly and easily from side to side with good range of motion and without undue effort (Ratcliff, 1982).
- Cb. _____ abnormal movement: jerky, writhing, or dystonic movement (Dworkin and Culatta, 1980a), such that discrete and purposeful action is interrupted by spasmodic motions. The tongue has too much or too little muscle tone to carry out action (Ratcliff, 1982).

5. TONGUE ELEVATION

The subject is asked to gently bite down on a one-inch tongue depressor held on its side between upper and lower first molar (left or right),¹ and asked to raise the tip of his tongue as high as possible and then lower it as the examiner repeats, "up - down" for five trials (Dworkin and Culatta, 1980a). Check either (a) or (b) for each of the following signs:

- Aa. _____ normal range: the tongue-tip should approximate the cutting edges of the upper incisors during upward action (Dworkin and Culatta, 1980a). Children under five years of age may show an anteriorly directed tongue-tip pattern in place of lingual elevation (Mason, 1980).
- Ab. _____ abnormal range: limited range in which the subject attempts to contact the cutting edges of the upper incisors but is unable to do so (Dworkin and Culatta, 1980a).
- Ba. _____ normal frenum: the frenum is sufficient to allow the tongue-tip to contact the alveolar ridge (Peterson and Marquardt, 1981).
- Bb. _____ abnormal frenum: short frenum which restricts the tongue, not allowing it to contact the alveolar ridge. The tongue blade will look like the top of a heart when the subject attempts to protrude it (Peterson and Marquardt, 1981).

6. ANTERIOR TONGUE STRENGTH

The tip of a strain gauge assembly is placed between the upper and lower central incisors with a chin piece and a forehead piece restricting extraneous movement. The subject is asked to push against the tip of the strain gauge assembly with his tongue as hard as he can and keep pushing hard until the examiner tells him to stop.¹ As the subject pushes against the strain gauge assembly, record the following objective data:

- A. _____ maximum degree of strength measured to the nearest millimeter.

7. LATERAL TONGUE STRENGTH

The tip of a strain gauge assembly is placed in the center of the subject's cheek. The subject is asked to push his tongue-tip against the inside of his cheek and thus against the tip of the strain gauge assembly. The subject is to keep pushing as hard as he can until the examiner tells him to stop.¹ As the subject pushes against the strain gauge assembly, record the following objective data:

- A. _____ maximum degree of right side strength measured to the

nearest millimeter.

- B. _____ maximum degree of left side strength measured to the nearest millimeter.

8. LINGUAL DIADOCHOKINETICS

The subject is asked to repeat as rapidly and evenly as possible the (tuh) sound until the examiner tells him to stop. The examiner demonstrates (tuh-tuh-tuh) for at least three seconds. The same procedure will be followed for (kuh). Two trials will be given for each sound (Dworkin and Culatta, 1980a). The subject will produce the sound for ten seconds. Check either (a) or (b) for the following signs:

(tuh) (kuh)

- Aa. _____ normal syllable production: the subject produces syllables using the correct phoneme each time (Dworkin and Culatta, 1980a).
- Ab. _____ abnormal syllable production: the subject produces imprecise syllables, not using the correct phoneme each time (Dworkin and Culatta, 1980a).
- Ba. _____ normal rate: the subject produces syllables at a rate of greater than ten syllables for ten seconds (Emerick and Hatten, 1979).
- Bb. _____ abnormal rate: the subject produces slow and labored syllables at a rate of ten or less for ten seconds (Emerick and Hatten, 1979).
- Ca. _____ normal timing: smooth rhythm and coordination of syllables so that they are evenly spaced in time (Dworkin and Culatta, 1980a).
- Cb. _____ abnormal timing: abnormalities in rhythm and coordination of syllables so that they are unevenly spaced in time (Dworkin and Culatta, 1980a).

9. SEQUENTIAL SYLLABLE RATES

The subject is asked to repeat as rapidly as possible (dippity-dippity-doo) until the examiner asks him to stop. The examiner demonstrates for at least five seconds. The same procedure will be followed for (lippity-lippity-loo) and (gippity-gippity-goo). The subject will produce the sound for five seconds (Dworkin and Culatta, 1980a). Check (a) or (b) for each of the following signs:

(dip) (lip) (gip)

- | | | | | |
|-----|-------|-------|-------|---|
| Aa. | _____ | _____ | _____ | normal syllable production: the subject produces syllables using the correct phoneme each time (Dworkin and Culatta, 1980a). |
| Ab. | _____ | _____ | _____ | abnormal syllable production: the subject produces imprecise syllables, not using the correct phoneme each time (Dworkin and Culatta, 1980a). |

Record the following objective data:

- | | | | | |
|----|-------|-------|-------|---|
| B. | _____ | _____ | _____ | rate: number of times the subject produces the nonsense word. |
|----|-------|-------|-------|---|

Check (a) or (b) for the following signs:

- | | | | | |
|-----|-------|-------|-------|---|
| Ca. | _____ | _____ | _____ | normal timing: smooth rhythm and coordination of syllables so that they are evenly spaced in time (Dworkin and Culatta, 1980a). |
| Cb. | _____ | _____ | _____ | abnormal timing: abnormalities in rhythm and coordination of syllables so that they are unevenly spaced in time (Dworkin and Culatta, 1980a). |

¹The basic instructions are those found in the source cited. The footnoted portion is added for clarification.

APPENDIX B
PARENT COVER LETTER

Date:

Dear Parents:

I am a graduate student in Speech-Language Pathology and am currently doing a study with four-year-old children who attend preschools. I am investigating the relationship between the children's tongue structure and movement and their ability to pronounce words.

To do this I need to test four-year-olds who have normal intelligence (with or without speech problems). The testing procedures which I will be doing are commonly used in routine speech and language examinations.

Your child has been selected to participate in my study. I would appreciate it if you would support my study by allowing your child to participate.

If you have any questions or concerns, now, any time during, or after the study, I would be happy to discuss by study and the procedures with you. Please feel free to call me at (714) 796-3959.

Please return the consent form to your child's teacher to show whether or not you give permission for your child to take part in this study.

I appreciate your support. Thank you very much.

Sincerely,

Donna Swenson
Graduate Student in Speech-Language Pathology

APPENDIX C

PARENT CONSENT FORM

I have been told that this study will involve children who attend an unimpaired preschool classroom. The purpose of this study is to compare children's tongue structure and movement with their ability to pronounce words.

I have been told that each child will be asked to do the following tests which together will take 30 to 40 minutes to perform for each child.

1. Listen to quiet sounds with earphones on the child's head and raise his hand when he hears each sound given.
2. Point to pictures or objects named.
3. Say the names of objects in pictures.
4. Move his tongue from side to side, press his tongue against an instrument which measures tongue pressure, and make various other tongue movements.

I have been told that, while there is no direct benefit to the children, in allowing my child to participate in this study, I will be helping contribute to research and furthering the understanding of how speech develops in children.

I have been told that the examiner may take a picture of my child's face, obstructing the eyes and hair, and record the voice of my child on tape. The pictures and recordings of my child become the property of the researcher and may be used for instructional or research purposes.

My child's participation in this study is voluntary and I may withdraw my child from the study at any time unconditionally and without prejudice to my child's preschool program.

I have read the contents of this consent form and have been given a copy of this form.

_____ I have read this consent form and hereby give permission for my child to participate in this study.

_____ No, I do not give permission for my child to participate in this study.

Signature of Parent or Guardian

Date

Witness